

A CONTRIBUTION TOWARD A KNOWLEDGE OF THE MOUTH PARTS OF THE DIPTERA.

BY PROF. JOHN B. SMITH.

“The mouth parts of Diptera are wholly suctorial, and differ from those of the Lepidoptera in that all the component parts may be brought into use. They differ not a little, however, in different flies, as might be supposed from their diverse habits. In some they are adapted for piercing animal or vegetable substances, and are, in consequence, firmer and more slender; in others, and by far the greater number, they are adapted only for sucking up juices or such substances as may be dissolved by means of their saliva. Grains of pollen have been observed in the digestive organs of the Syrphidæ, and other flower flies, but, as a rule, fluids alone serve as food. Many have the proboscis wholly retractile into the oral cavity, and furnished with one, or even two hinges, by which, when at rest, it may be folded up. In others the proboscis is not retractile, and either projects in front, or backwards under the abdomen. While it is usually short, it may be as long or longer than the body. Finally, a few species have the mouth parts rudimentary, and take no nourishment in the adult stage.

“The different parts consist of the labium, the maxillæ, maxillary palpi, mandibles, hypopharynx and labrum-epipharynx, a term used by Dimmock, to whom our clearest knowledge of the mouth parts of Diptera is due. The labial palpi are thought to be wholly wanting. The labium is always present, more or less fleshy, and provided with muscles, and is grooved or channelled upon the upper side to receive the other parts in a sheath completed by the labrum. At its tips there is a pair of joints called the labellæ. In the mosquito these are small, where they serve simply to guide the piercing portion between them, the labium itself being bent backward beneath the thorax in its middle. Very often they are large and more fleshy, and on the inner sides have a roughened surface composed of the pseudo-trachea, which, as in the house-fly, serve as a means of attrition. The maxillæ and mandibles are frequently absent, the latter most often; when present they are slender and bristle like. The maxillary palpi are always present, and consist of from one to five

joints, in the latter case often long and whip like; they are more or less hairy, and are attached near the base of the proboscis on the outer side, where the maxillæ coalesce with the labium. In addition to the two pairs of maxillæ and mandibles there is a third, unpaired organ which is free, the hypopharynx. It is usually present, and tube like, for the passage of saliva, the outlet being near the tip on the upper side; its tip may be smooth, lance like, or hairy. Its upper side is continuous with the under side of the pharynx, and the whole, or in part, may coalesce with the labium below. Finally, the largest, except the labium and uppermost, as well as the most important organ is the labrum-epipharynx, which is deeply channelled on the under surface and converted into a canal by the apposition of the hypopharynx below. It is through this channel that all the substances used as food must pass. The two parts of which this organ is composed, the labrum above and the epipharynx below, are sometimes separable by means of caustic potash, but are never so in life. It may terminate in a single point, or in several minute ones, as in the mosquito. It forms, as before stated, a covering to the channel in the labium, and may be separable at the will of the insect, as is readily seen in the mosquito when biting, or it may remain tightly closed, as in the house-fly."

The above quotation, from Dr. Williston's article in the "Standard Natural History," is given as representing more clearly and definitely than any other, an account of the present state of our knowledge of the structure of the Dipterous mouth. Kraepelin's studies have made some few modifications, but none in essentials, except that he says there is no epipharynx, and Dr. Packard's most recent text books give practically the same account. To this must be added that Dr. Macloskie calls the chitinous enclosure of the muscid proboscis, above the labellæ, the operculum, and the chitinous framework at the base of the mouth system, the fulcrum. This latter he considers as a modified endocranium, and the function as a sucking stomach.

As a result of my own studies, I have concluded that the mandibles are present only in the rarest instances; that the proboscis and its labellate development have nothing to do with the labium, but are maxillary developments; that the labial palpi are traceable as rudiments in many forms, and that neither labrum, epipharynx, nor hypopharynx enter at all into the composition of the functional mouth parts of the Diptera!

This means, practically, that all previous investigators had completely misunderstood the nature of the Dipterous mouth, and puts me to a strict proof of my assertions. To do this it may be useful to state how I, not a special student in the Diptera, reached this conclusion.

In a study of the "Horn fly," *Hæmatobia serrata*, the mouth parts were examined and figured, to show how the "biting" was done. The nomenclature adopted, agreed with that above given by Williston. To illustrate some lectures and papers during the Winter of 1889-90, several carefully prepared slides were required, and, among others, the Dipterous mouth was well represented. Finally, during the Summer of 1890, a lecture on the mouth structure of insects, prepared as a part of a course delivered at the Cold Spring Laboratory of Biological research, brought to my mind very forcibly, the want of agreement in the line of development, for the mandibulate and haustellate series. A number of diagrams, prepared to illustrate these lectures, and now adorning the walls of my laboratory, brought me to a gradual comprehension of the homology which I am now trying to prove.

To understand exactly the line of investigation, it becomes necessary to look for a moment, at the structure of the mandibulate mouth. A generalized view is given by Newport's figure of *Andrena*, which

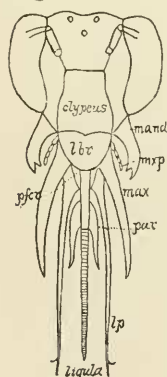


Fig. 1. Head of *Andrena*. After Newport.

is here reproduced in order to fix the comparative location of the parts, and without any guaranty of correctness in detail. We find the mandibles at the extreme side of the mouth, next the clypeus, and above the labrum, which forms a frontal cover or shield, to the base of the mouth parts. The maxillary palpi are below and within; between the mandibles and the maxillæ. Central, is the labium with its development of ligula, paraglossa and palpi. The mandibles have no point of attachment to either maxilla or labium. The labium is called the lower, the maxilla the upper jaw, but practically, in many cases, the two are on the same plane, and, quite frequently, the labial appendages are before or concealed in part by the maxillary development.

The maxilla, illustrated by a species of *Polistes*, probably *metricus* Say, is composed of the cardo, the stipes, the subgalea, the lacinia,

the galea, the palpifer and palpus, all of which are shown in the figure.

The galea is often palpiform, and in that case the lacinia becomes developed into a scraping or brushing organ, sometimes adding a digitus, but perhaps more usually, the galea is the most developed organ, and is formed as the brush, while the lacinia is reduced as in *Polistes*, or, still more obviously, in *Macroductylus*, where it becomes a mere rudiment, while the galea becomes highly developed.

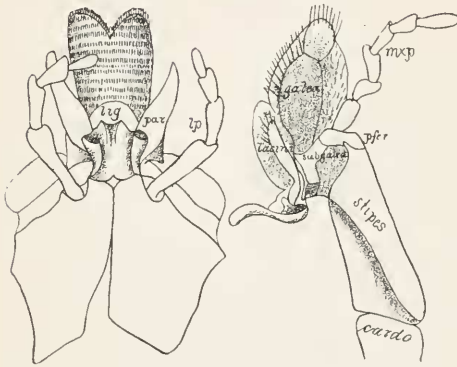


Fig. 2. Mouth parts of *Polistes metricus*.

To this development of the galea, the facts that it is two jointed, and that it tends to form processes or specialized hairs and bristles, particular attention is drawn.

The labium in its simple form, consists of a central ligula, which is rarely paired, lateral paraglossae, and the labial palpi, all of which are attached to the mentum. Neither ligula nor paraglossae are usually jointed, except perhaps, in the Orthoptera. Often they are united to form a single organ, the ligula, practically imbedded in the united paraglossae. In the *Apidæ*, or many of them, the ligula becomes elongated, ringed, but not jointed, the paraglossae become enveloping membranes for a portion of the distance, and the palpi also become elongated as the figure of *Andrena* shows. To the peculiar labial development in *Macroductylus*, attention is here called, but this will



Fig. 3. Mouth parts of *Macroductylus subspinosus*

be again referred to later. The development in *Polistes*, where there is a bladder-like membranous expansion, covered with sensitive hairs (the hypopharynx?), is also to be noted, with the further note that it is not paired or jointed, but a mere membranous development or expansion, a true lapping organ.

The hypopharynx and epipharynx are fleshy, internal mouth structures, supposed to represent the tongue and palate of vertebrates.

Now let us see what developments must have taken place if the accepted explanation of the Dipterous mouth parts is correct. The labrum, from an external, head piece, shielding the mouth, becomes a true, functional, internal mouth organ; the mandibles become part of the maxillæ and migrate within the palpi; the galea disappears, and the whole maxilla becomes reduced to a single piece; the labium becomes most enormously developed, and adds two joints; the labial palpi disappear, the paraglossæ are wanting, and the ligula is not mentioned. But, on the other hand, besides the labrum, the epipharynx and hypopharynx become functional, chitinous, and, from a sensory or tactile development, become mechanical.

How this striking change in the functions and location of parts occurred, had never been explained, and that was my task. I assumed the correctness of the theory that insects, being developed from a common stock, would somewhere have a generalized type of mouth; or, at least, that there would be such variations of development, that the points at which the mandibulate and haustellate mouth branched, might be discovered. The natural point at which an explanation might be sought was not among the highly specialized forms such as *Musca*, but was rather among those forms in which division of the mouth parts reached the extreme, and thence the work would be in the direction of the specialized forms. A short study of the forms allied to *Bombus*, *Xylocopa* and *Apis*, among the Hymenoptera, showed that the tendency in the labium was nowhere toward a segmentation, but to an elongation; and my first object was to try and identify, among the Diptera, the true labium and the paraglossæ. Then those forms in which the proboscis was incompletely developed, were sought, and, finally, in a minute midge (*Simulium* sp.?), which swarmed at Angelsea, N. J., early this Spring, and almost drove me distracted by its painful bite, I found the solution!

Dr. Riley kindly sent me some specimens of the Buffalo gnat for study, and I had then the species which showed not only all the parts

ordinarily recognized, but also the true labrum and mandibles. This is the only species I have seen in which the mandibles are present, and with this species I shall start, using at once the nomenclature which I consider correct, and which I hope to establish.*

In this species there projects from the middle of the front margin of the oral opening (clypeus?), a long, flat, chitinous process, reaching to the end of the mouth organs, supported each side by a rod reaching to within the clypeus, and, at the end of this central piece, resting

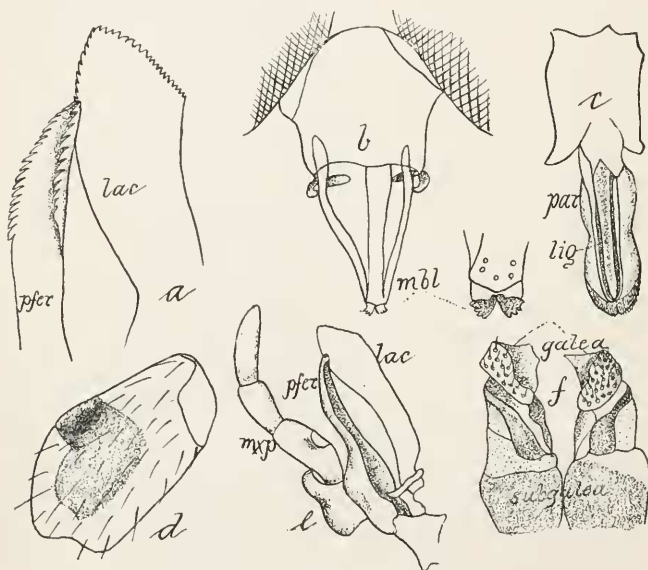


Fig. 4. Mouth parts of Buffalo gnat.

on a muscular base supported by the lateral rods, are the minute mandibles, set obliquely. They are red-brown, solid, three toothed, and grooved inwardly, in all respects like the mandibles of some Coleoptera and Neuroptera, and absolutely unmistakable. It requires a good objective on a well prepared specimen to see them at all, but a one-fifth brings them out fully and clearly. These mandibular supports are in front of the other mouth parts, and behind them, most prominently, are the parts which I consider the subgalea

* In the Report of the Entomologist 1886, Dr. Riley's account of the Buffalo gnat is illustrated (Pl. viii, fig. 2) by a figure of the head, which is very accurate, and in which the mandibles are properly shown. The meaning of the structure was not recognized by either author or artist.

and galea, shown at *f*, fig. 4. These are here completely divided, the basal part of each broad, mostly chitinous, and forming more than half a cylinder. Above this are two segments, representing the joints of the galea, less chitinized, the basal segment largest, forming a shell, inside of which is the lacinia, but outside of which is the palpifer, bearing the maxillary palpi at its base. This latter piece, which may be stipes rather than palpifer, is also produced and forms a piercing organ. It passes outside of the galea until near the tip of the basal joint; here the cylinder formed by the segment is incomplete, and the palpifer enters to join the remainder of the piercing mouth parts. The lacinia is attached by a chitinous rod to this palpifer, and runs within the galea for its entire distance. At *e*, fig. 4, the lacinia, palpifer and maxillary palpus are shown separated from the rest of the mouth parts. At *a*, fig. 4, the tips of the lacinia and palpifer are shown, greatly enlarged, to bring out the serrated armature. The palpus contains on joint 2 a round pit connecting with a pocket of darker colored cells, as shown at *d*, fig. 4. Central to the mouth is the structure shown at *c*, fig. 4, composed of a broad basal plate, the mentum, bearing a stout chitinous process, showing evidently its paired character, especially at tip. These are the paraglossæ, and within the groove formed by these parts united at bottom, lies the ligula.

I omitted to state what fig. *f* distinctly shows, that the terminal joint of the galea consists of merely a shell, not more than half a cylinder, beset on the outer side with short hair, arising from fleshy tubercles. In this insect I found the Dipterous mouth parts most divided, and, so far as the galea is concerned in the condition most nearly approximating that of the mandibulate mouth. What I term the palpifer may be really the stipes, and the real palpifer may be the basal segment of the palpus itself; but, as will be seen in *Erax*, the palpi arise directly out of this part, and it is not a matter of very serious import, for my present purpose, to settle this question definitely. There is no outer covering of membrane to the mouth parts, and this is a point that requires notice, because of the important influence which that structure exercises upon the development of the palpi.

It may not be unnecessary to state that all the drawings made for this paper were sketched by the use of the camera lucida, and that the irregularities and lack of symmetry are faithful reproductions of what is seen in the slide itself. The image was thrown on a slightly

inclined board, and there is a trifling distortion due to that cause; but which does not in the least interfere with accuracy of representation.

A close relative of the Buffalo gnat was found in a minute midge swarming at Anglesea, N. J., in May, and which showed a very distinct advance in mouth structure. The insect is about 1.5 mm. in length, and the head does not exceed .5 mm. in diameter. The task of separating out the mouth parts, small even in proportion to this head, was a difficult one, and a $\frac{1}{8}$ objective was necessary to make out all details. At *a*, fig. 5, the subgalea and galea are shown

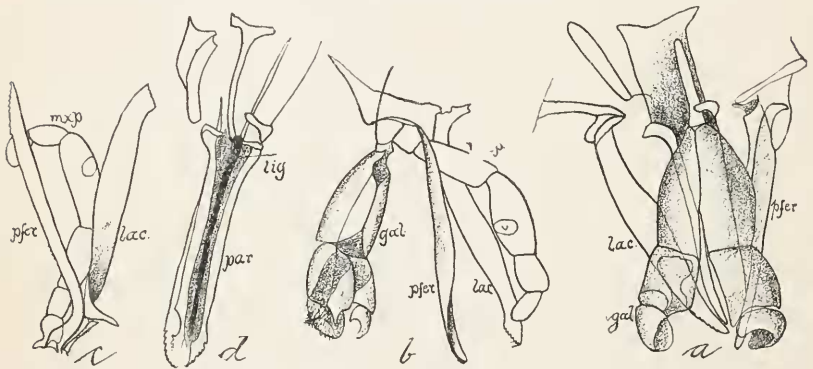


Fig. 5. Mouth parts of Anglesea midge.

from behind, the subgalea now united at base; but the joints of the galea are separate, and there is no trace of pseudo-trachea. In general structure there is no great departure from that of the Buffalo gnat, except that the subgalea unite at base, and are articulated to a stout chitinous piece, which may be the remnant of the cardo. There is a somewhat similar structure in the mosquito at the base of the "labium," and the line of development is directly from a form of this description to the mosquito, in which the labella also do not contain pseudo-trachea. In this figure we also note the method in which the lacinia and palpifer enter the galear cylinder, and the paired character of the structure is maintained. This is important, for the membranous expansion of the labium, seen in some Odonata and in *Polistes* (fig. 2), shows no trace of a paired structure. The tendency to a fragmentary condition of the joints is also worthy of attention, as here we notice the beginning of what will be afterward seen, as the chitinous supports of the labella in *Musca*. It is noticeable here, too, that the maxillary parts are not central, and arise outside the

median or labial structures. At *b*, the galea and the lacinia, palpifer and palpus of one side are shown as they appear separated out, and at *c*, the remainder of the maxillary structure appears. It is interesting to note that the palpi are furnished with a sensory pit as in *Simulium*, of which, indeed, this is likely a member. Easily separable from the maxilla, without the destruction of any chitinous parts is the labium, shown at *d*. In this the ligula, while obvious in the preparation, is not separated out, because I could not manipulate my needles under the high power necessary. The paired nature of the paraglossæ is obvious, and this could not have anything to do with the labrum, from the simple fact that I do not know of a case in which the labrum is paired, and of no case in which it is an internal mouth organ. The labrum must also be articulated to the clypeus at base, if homologies are to be preserved, and this clypeus must then be the square plate seen in figure 4, *c*, and again in the figure of *Tabanus atratus*. This would bring the clypeus entirely inside of the head, where it does not belong, while if we take it to be the mentum, not only is its place natural, but the attachments to it have a natural significance, and the development is an easily explicable one; which is certainly not so if we refer to the labrum shown in figure 1, and are compelled to imagine this modified into a tubular or channelled prolongation. This interpretation also makes it unnecessary to account for the development of a fleshy, sensory organ, into a chitinous, mechanical structure.

Leaving the development of the galea for a moment, an examination of the mouth parts of

Tabanus will be interesting. Fig. 6 represents the maxillæ and labium of the large black species which I take to be *atratus*. In examining the central organ here, we find the broad basal plate representing the mentum, the united paraglossæ, which here show no observable suture as in *Simulium*, the central ligula, and, most

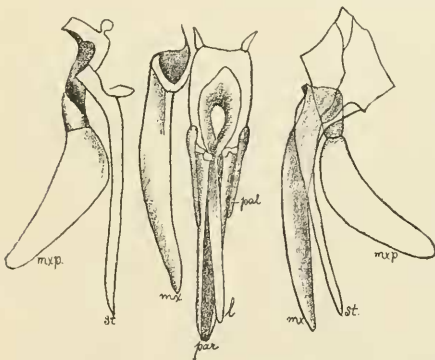


Fig. 6. Mouth parts of *Tabanus atratus*.

interesting of all, the rudimentary labial palpi, closely applied to the sides of the paraglossæ, but reaching some distance beyond them

along the mentum. The palpi are not at all functional, but are rigid, not articulated, yet not entirely connate with the *paraglossæ*. In *Tabanus lineola* (I feel safe in this determination) the palpi are still more distinct, but not yet free, nor have I found any species in which they are functional. I have a very strong conviction, however, that somewhere in the Diptera some vicious beast will be found in which the palpi are entirely free, and possibly functional. The figure of *Tabanus lineola* is here inserted to show the relative position

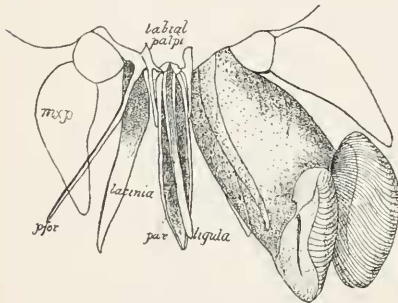


Fig. 7. Mouth parts of *Tabanus lineola*.

of the parts, as attached to the head. No effort has been made to differentiate the galear structure, which is highly specialized here. Returning to the study of fig. 6, we find the right hand figure to represent the lacinia (*mx*), the palpifer (*st.*) and maxillary palpi (*mxp*), in their relative positions, attached together. The lacinia alone (*mx*) is shown to the left of the labium, and at the extreme left are the palpus (*mxp*) and palpifer (*st*). This figure shows the development of an important tendency in the palpi. It will be noted that, at the base, there is but a flat strip connecting with the base of the palpifer, and that the joint becomes a complete cylinder only near its tip. The chitinous band forms the real base of the palpus, but the membranous extension from the margin of the head envelopes the base of the mouth, and the palpal joint first becomes complete on the outer side of this membrane. That is to say, outside of the enveloping membrane, the palpus is complete, but within the head the joint becomes partly muscular, and the chitinous cylinder is incomplete. This is important, for it is the beginning of the complete separation of the palpi from the functional mouth parts.

The next step will be noted in the Asilidæ, of which *Erax* sp. and *Asilus sericeus* will be figured.

In *Erax*, we have at figure 8, *c*, the appearance of the mouth parts from the front, showing the attachment of the palpi (the dotted portions representing membrane) and the method in which the palpifer enters the galear structures. The terminal joints of the galea are completely separated, but the basal joints are united beneath. The

structure of the sensitive portions of the terminal joint is shown at *a*, and consists of a series of fleshy tubercles on a membranous base, the tubercles all furnished with rather stiff hair.

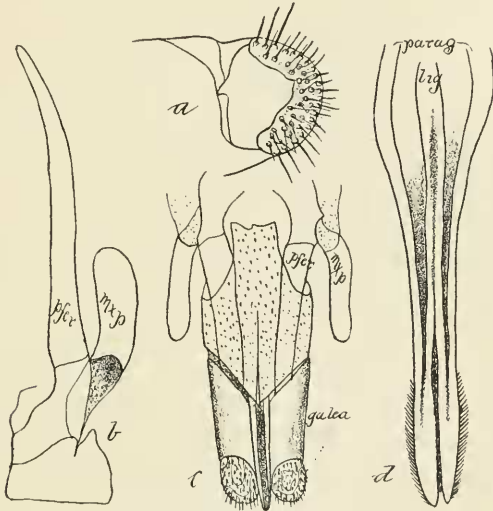


Fig. 8. Mouth parts of *Erax* sp.

At *b*, is shown the structure of the palpifer and palpus, the latter single jointed and showing the same tendency noted in *Tabanus*. At *d*, is shown the labium, the ligula central, not easily separable from the paraglossæ, which very evidently show their paired character in this species.

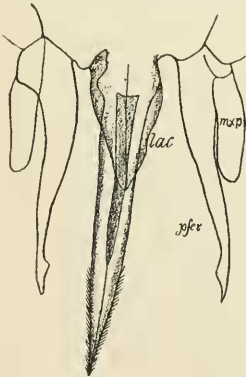


Fig. 9. Mouth parts of *Asilus sericeus*.

unfortunate insect has been

In *Asilus sericeus*, fig. 9, the galear development is cut away, and we note the relative position of the parts. We notice here, too, what is of some importance, that the lacinia are reduced in size and really rudimentary, thus forming the intermediate step to *Stomoxys* and *Hæmatobia*, where it is entirely wanting. So, also, the galear structure reminds one strongly of *Stomoxys*, especially in the structure of the tip.

Of other piercing species I will call attention only to the mosquito. This un-

add none of my own, save that of the tip of the galea. This differs somewhat from Dr. Dimmock's figures of the same structure; but the species are different, and I have found that no two of the five species examined agree, nor do any agree with Dr. Dimmock's species. It is readily seen that while we have here in essentials the chitinous structure of *simulium*, yet we get a tendency in the terminal joint to form a mere chitinous cap, a breaking up of the chitine into fragments and a filmy covering over the inner face—the rudimentary labella.

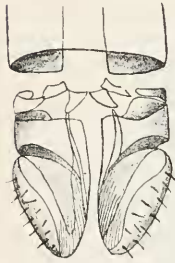


Fig. 10. Galea of mosquito.

At this point we drop the piercing flies, and now we find in point of development a steady loss in the piercing organs, and as regular a gain in the galea. It is worth noting, too, that while the fulcrum in the piercers is not developed where the mouth parts are much divided, it becomes prominent as the maxillary development becomes weak.

In *Culex* there is a very pretty little fulcrum, much like that of the *Leptid*, hereinafter figured. In *Stomoxys* there is a very decided development. It is a suggestive fact that when the mentum disappears, the development of the fulcrum begins.

Bombylius sp., in which the mouth parts are elongated, forms a good subject for the next figure.

This is one of the species in which the proboscis is carried straight forward, and the flexion is so strong that it is not easily overcome.

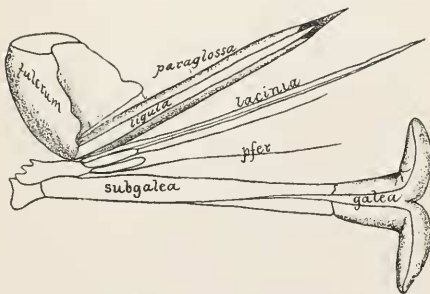


Fig. 11. Mouth parts of *Bombylius* sp.

The fulcrum of the figure is therefore seen flexed upon the labium, to which it is articulated at its base. The ligula is quite closely united with the paraglossæ, and is so shown in the figure. The lacinia are flattened strips arising at the sides of the labium and partly enveloping it. The pal-

pifer is a fine seta, shorter than the lacinia or labium, and with a basal extension above the insertion of palpi. This is an interesting fact, as a beginning in the peculiar change undergone by this part.

The galea is distinctly divided at the tip, forming evident lobes, covered with a delicate membrane, which is wrinkled, but is not furnished with pseudo-trachea.

Because nearly allied to *Bombylius* we may now examine *Anthrax*, although not nearest in any direct line of development save for the palpifer. As in *Bombylius*, the proboscis is so fixedly projected forward, that it is difficult to straighten, and the mouth parts are therefore figured lying against the fulcrum. Here, too, a study of the method of union of labium to fulcrum, points to the mentum or submentum, as concerned in the development of that organ. The lacinia have become broad, roughly shaped like a spear-head; they envelope the labium, and, with it, lie in the galea. The subgalea is

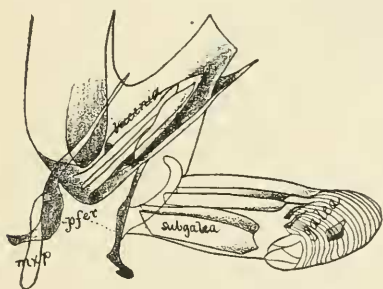


Fig. 12. Mouth parts of *Anthrax*

distinctly paired, each side piece divided longitudinally, so that here we see the beginning of the central supporting rods, well developed in *Eristalis*, and also the foundation of the structure forming the broad back plate of the operculum or medi-proboscis. The labellate development of the galea is well marked, though the lobes are not well divided. The chitinous parts of the two joints are reduced to two pairs of small plates, which alone indicate the original nature of the structure. The most interesting character is in the palpifer. Heretofore we have seen the palpus attached at or near base, and always in forms in which the proboscis is not flexed. In *Bombylius* we saw the first approach to a basal prolongation, which in *Anthrax* is much more marked. The palpus is small and feeble; the basal prolongation of the palpifer is not long, but it is broad, flattened, roughened as for muscular attachment, and very thoroughly chitinized. The apical process is very decidedly less chitinized, and does not extend to the tip of the labium. As is usual, its point of insertion is outside of the galea, which it enters with its apical process, very close to base.

Beginning a new series, not so closely connected with those forms in which the mouth parts are adapted for piercing, are a number of species in which the galea is well developed into the labellate form still, however, retaining the marks of its origin in a remarkably perfect condition, and having the proboscis not hinged.

First among these is a small *Stratiomyid*, of which, unfortunately, my material was too scant to make out all the parts as thoroughly as I desired. It is a small species, caught on the windows of my laboratory, and the figures are from one of the two specimens taken, the other being spoilt in dissecting. The galear structure shows excellently well. The subgalea is evidently divided, surmounted by the two galear joints, each of which is distinct, outwardly chitinous,

inwardly with a delicate membrane, in which the pseudo-trachea are well developed. In the specimen, more obviously than in the figure, the character of the central chitinous supporting rods as fragments of the galea joints, is evident, and we have here, practically, the structure of the

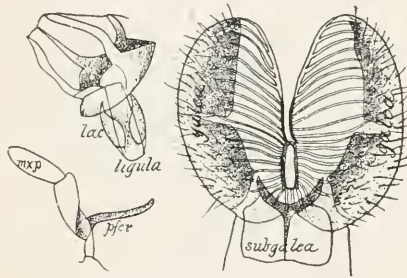


Fig. 13. Mouth parts of *Stratiomyid*.

Simuliid galea, the inner face completed by a membranous expansion and tracheate.

The palpifer is here reduced to a mere rudiment, without any basal process, and in natural position reaching barely to the center of the galear envelope. The labial structure is peculiar, and I regret that I had no specimens for further study. There is a fulcrum very like that found in the mosquito, and entering that centrally is the flattened, slightly concave labium or ligula, in which I could not trace any division of parts. The lacinia is a mere enveloping lappet,

whose point of attachment is not satisfactorily made out. Altogether, the form is a valuable one, and the *Stratiomyidæ* may present characters of great interest where abundant material for dissection is at hand.

A very distinct advance is seen in the *Leptidæ*, species undetermined. The

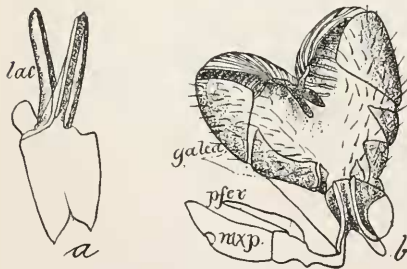


Fig. 14. Mouth parts of *Leptid*.

subgalea is united, and, while the chitinous parts of the galea joints are well distinguished, the enveloping membrane covers the whole

inner side, and the pseudo-trachea are confined to the apical expansion. The chitinous fragments have been carried upward, and on them the tracheate system rests. The structure of the palpi does not differ very essentially from *Stratiomyia*, as can be seen by a comparison of figures. Here, however, there is developed a sensory pit in the palpus, and the palpifer is still further reduced. Perhaps it may be in order to state that the apparent segmentation of the galea, on the right of the figure, is really a fracture, and that the left side illustrates the perfect condition. The labium is shown at *a*. There is a broad, large, basal mentum, reminding of the Tabanidæ, to which the ligula and paraglossæ, closely united, are attached. The lacinia, not articulated to the mentum, but almost completely enveloping the labium, is shown slightly separated from it.

This is also one of the species in which the proboscis is not hinged. The fulcrum does not show in my specimens, and I made no effort to seek it, as I was not studying its development. The presence of the distinct mentum would, however, indicate the absence of this organ.

Next comes *Tipula* sp., a form in which the maxillary palpi are well developed. No effort was made to study any but the galear

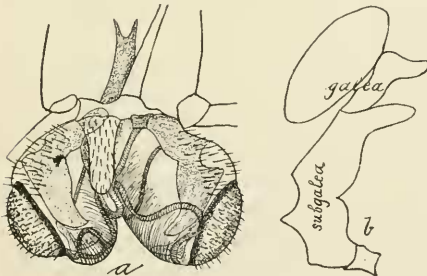


Fig. 15. Mouth parts of Tipulid.

structure, though several species were examined, as nothing of special interest was obvious. The galea is here, in some respects, most perfect. The chitinous parts are flattened, and, with the exception of the terminal cap, are entirely within the membranous envelope. The character

of the structure is best seen at *b*, figure 15, where the chitinous structure is separated off and figured. The two sides here are entirely separated, the joints are well marked, and a study of this species alone leaves an overpowering conviction of the true homology of the parts, which could not possibly be reconciled by any theory of labial development. Within the sac enclosing this galea, is a series of large tracheæ, uniting to a few trunks running into the head. There seem to be no true pseudo-trachea, but there is a series of transverse wrinkles covering the inner face. No dissections were made to get at the other structures, since the galea was all I was seeking for here.

Some specimens of a Dolichopodid, prepared for examination, proved failures, owing to a lack of differentiation in the mounted material, and only a very unique character on the galear envelope was noted.



Fig. 15. Pseudo-trachea (?) of Dolichopodid.

Instead of the pseudo-trachea, or the wrinkled structure often representing it, we find here a series of geminate tubercles, decreasing in size from the margin, and ending in the membrane. I have not seen this appearance in any other species, and could not study more than the one species of the family from lack of material.

As suggested above, in all of the forms last treated, the proboscis

is not hinged or folded, and in none do we find any trace of a basal prolongation of the palpifer; that organ itself becoming very much reduced. In all the following species the proboscis is hinged and the galea development is of the same type. This type is best illustrated by a



Fig. 17. *Eristalis transversus*.

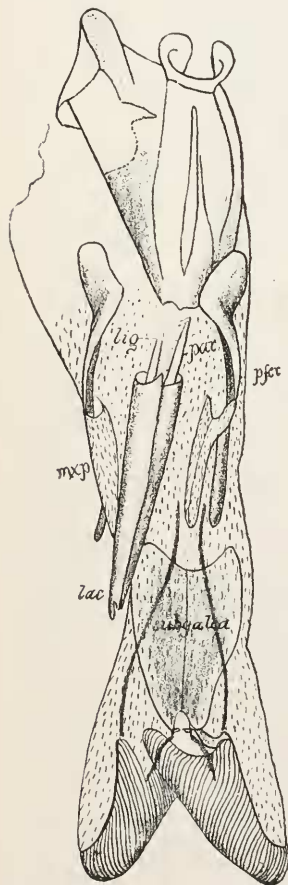


Fig. 18. Mouth of *Eristalis tenax*.

enveloped by the lacinia, which do not, however, extend to the base. The ligula is well distinguished, and,

as usual, the articulation is very closely to the fulcrum. Laterally we see the palpifer, now completely without chitinous connection with the rest of the maxilla, stoutly produced toward the base and with but a small apical process. The palpi themselves are almost completely separated from the palpifer, except by muscular attachments, and the blunt character of the apical process itself, indicate its disuse as a piercing organ, almost as well as the fact that it is not equal in length to either the labium or lacinia, and so does not reach to the tip of the central aggregation of mouth parts. In fact here, more than in any other species heretofore figured, the palpifer is disconnected from the other mouth organs, and first changes its function from that of a piercing organ to one offering assistance in flexing and extending the proboscis as a whole.

The peculiar extensibility of the membrane enveloping the mouth parts is not confined to the species figured, but is notable in all of the five species of Syrphidæ examined. It requires no force to extend it, and is not elasticity; but neither is the extension spontaneous in macerating or preservative media. In placing the prepared specimen on a slide, in position preparatory to mounting, the extension is readily made with a blunt needle, and its limit is easily known. Whether the insect itself has the power of making the extension voluntarily I do not know, and observation on living specimens would be required; it is, however, reasonable to assume that the power exists.

Eristalis is interesting in another respect, for, in the three species examined, the labrum, in its proper position, and normal in shape, marking the frontal margin of the oral opening, is easily distinguished; its claim to form a part of the internal mouth is thus absolutely negated, for every organ represented in the mosquito is also represented in *Eristalis*, and as the labrum exists independently of all, it is of course an absolute impossibility that it can find a homologue in any of these parts.

Another of the Syrphidæ, *Sphaerophoria cylindrica*, may be usefully presented here, as an advance in the basal development of the palpifer. Only the necessary parts are figured, as the structure does not in other respects differ from that of *Eristalis* in any important features. The palpifer to the right of the figure is shown complete, and without the palpus. The apical development is seen to be small, merely rudimentary in fact, while the basal prolongation is very decided, with broad, flat surfaces for muscular attachment. The

palpus, seen at the left of the figure in its relation to the palpifer, is completely separated by muscular attachments, while retaining a close proximity to it, so that the relationship is easily manifested.

In a common muscid species, perhaps a *Lucilia*, with bright, shiny, yellowish to green bronze thorax, we note a still further separation of palpus from the palpifer, and a more complete specialization of the latter organ. The palpus now retains no apparent relation to the chitinous parts of the mouth, the base arising from a more chitinized strip of the enveloping membrane. Of the piercing character of the palpifer so little trace remains, that its true character could not be suspected without a study of the species previously figured. In fact, there is now a complete change of function, for I attribute to this part a prominent share in the flexion of the proboscis. The part is not seen in any species examined by me, in which the mouth parts are rigid, like *Tabanus*, *Simulium*, *Erax* or *Culex*, though in the latter there may be a small basal prolongation similar to that of *Bombylius*. Here, the flexion is a very limited one, however, unaccompanied by any retraction. In forms like *Leptis* and *Stratiomyia*, where there is mere retraction without flexion, there is no basal prolongation whatever, and, as no piercing effects are required, there is a simple reduction in size, without any change of function. In the development of what may be termed the muscid type, in which the mouth parts become entirely enveloped in a membranous extension of the oral opening, and the sac thus formed becomes entirely retractible within the head, a new adaptation becomes necessary. The character of the mouth has changed; piercing organs are no longer required; the palpifer, from its situation as the exterior part of the maxillate structure, gives the greatest opportunity for leverage and the modification begins in the direction of

Fig. 19. Operculum and palpifer of *Sphaerophoria cylindrica*.



a process for attaching the muscles. It is notable that, in the beginning, the basal process is short, broad and flattened, strongly roughened for the muscular attachments; a mere appendix to the functionless, but still well developed piercing organ. As the development progresses the piercing organ becomes smaller, until it is

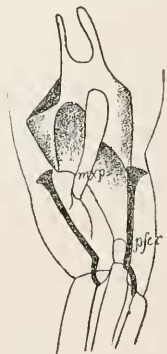


Fig. 20. Fulcrum and palpifer of *Lucilia* sp.

rudimentary; the basal extension enlarges, or rather elongates, and, as it becomes longer, and the leverage becomes greater, it decreases in bulk, and becomes finally a chitinous rod. At first free, it gradually attaches itself by what must now be considered its apex, but was originally the base, to the base of the lacinia, and, as these disappear (*Stomoxys*) to the labial organ, so that it seems a mere appendage to this part, and remains attached to it on separating the structures.

In a careful preparation of the blow-fly, *Calliphora vomitoria*, intended to bring out the relative situation of the parts viewed later-

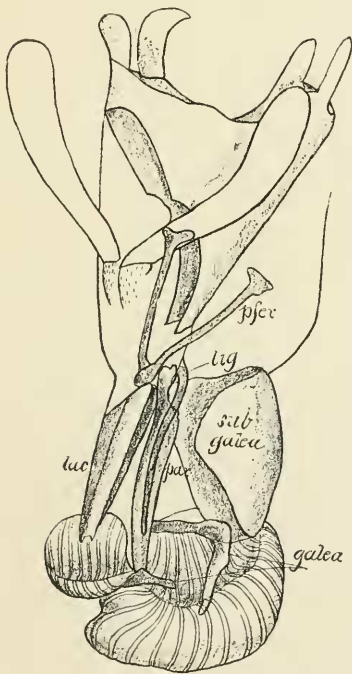


Fig. 21. Mouth parts of *Calliphora vomitoria*

ally, I was able to show, more clearly than I ever could in a flat preparation, the precise location of the separate structures. It will be seen that centrally we have the labium, with its united paraglossæ, and very distinct, central ligula, attached by a muscular hinge to the base of the fulcrum. In front of this labium, and partly enveloping it, are the lacinia, closely united, and forming the chitinous front margin of the operculum or medi-proboscis. Attached at the base of this lacinia is the palpifer, extending free along the sides of fulcrum, and by its muscular attachments elevating the proboscis, so that it rests with the lacinia between the palpi and against the membrane opposite the open front of the fulcrum. In connection with this flexed condition it will be of

interest to again refer to the figure (3 b) of *Macroclactylus*, as suggestive of a possible line of development for the fulcrum.

The palpi in the blow-fly are from the enveloping membrane, supported by a narrow chitinous strip, indicated in the figure by the dotted portion at base. The subgalea forms the posterior or chitinous portion of the operculum, and I can see no divisional suture. Attached are the galea, reduced to the well known chitinous supports of the labellate development.

Finally, I will add a figure of *Musca domestica*, the common house-fly, in which the parts are named in accordance with what I believe to be their true character. The figure is correct, save in the pseudo-tracheal system of the galea in which no attempt at accuracy was made.

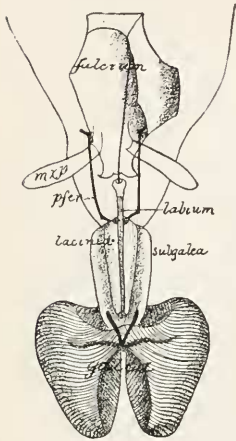


Fig. 22. Mouth parts of *Musca domestica*.

I have now covered a series, showing, as I believe, the homology between the mouth parts of the Diptera, and the typically mandibulate mouth. Many more specimens were examined than are here referred to, only those useful to my purpose being selected to figure, and only such characters being selected for study as bore upon the present inquiry. I have shown the presence of the true mandibles in *Simulium*, and their absence elsewhere. I have traced the "mandibles" of previous authors—from a stout, piercing organ, to the "great tendon"—and

have shown it to be a palpifer first, and an attachment for muscles flexing the proboscis finally. As a mere palpifer it may yet, in its development, represent as well the stipes, which I do not otherwise identify. I have proved the "labium" a mandibulate organ, and a modification of the galea. I have shown its original paired character, and its development to the typical muscid proboscis. I have proved its jointed nature, and have identified the chitinous supports of the pseudo-trachea, as the remnants of the original segments. The lacinia have always been recognized as the "maxillæ," and I have shown to what particular piece they are homologous. I have shown the mentum and the rudimentary labial palpi, and have homologized the labrum-epipharynx and hypopharynx with the ligula and paraglossæ.

In my studies I have followed a different line from that adopted by Dimmock, Macloskie, or Kraepelin. I made no sections of any kind, but studied each organ in its entirety, in its relation to others, and in its development. In other words, my studies were morphological rather than anatomical.

On mere philosophical and physiological grounds, I claim my interpretation of the parts as the true one. It is perfectly conformable to any natural theory of evolutionary development; it accounts

for every organ of the mandibulate mouth ; it requires no change of function for any organ ; the galea as a "scraping and tearing" organ being maxillary in its character, not labial ; the development required is simply a further development of the line started in the Hymenoptera, of which Cresson says : "mouth mandibulate, and with a lower lip or tongue,* *sheathed by the maxillæ*;" it requires no further segmentation of any structure ; it does not require the total loss of any part at *all* points of the series, nor does it anywhere require any unusual development or change from a sensory to a functional organ ; finally, it does not require any change in relative position of the parts.

I have not the least doubt that the series presented by me could be rendered much more conclusive ; but I am hampered by a lack of material, only the few species which I collected as I ran across them during the past season being at hand to draw from.

If my explanations are correct, some changes must be made in the nomenclature of the mouth parts in the Hemiptera as well.

SOME NOTES ON *ARÆOSCHIZUS*.

BY GEO. H. HORN, M.D.

Since my Revision of the family Tenebrionidæ in 1870, very little has been done beyond the description of new genera and species which have been discovered. All the species of the genus now under consideration have been rare in collections with the exception of *sulcicollis*, which was found by me in considerable number, and distributed liberally, thereby making the genus known in collections. In the meantime other collectors have, from time to time, found small numbers of one or other species, so that at the present time quite good series of all the species have accumulated in my boxes.

The species are all quite small, somewhat ant-like in form, but more depressed, and very sluggish in their movements. Their color is some shade of brown, the surface without lustre. The elytra are elongate-oval, the humeri rounded, the curve descending from the peduncle of the body. The surface of the elytra is costate, there being four elevated costæ on each side, excluding the sutural, of which the first and third are nearly entire, the others shorter. Between these costæ are two rows of coarse and deep punctures, never

* The italics are mine. The enveloping "maxillæ" are the galea.